Status of Resources for Information Technology to Support Health Information Exchange in Resource-constrained Settings

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Abstract: Various resources exist to support health information exchange (HIE). Both computerised and uncomputerized communication resources continue to be used in resource-constrained environments, like the Uganda health system to support HIE. Despite the rapid shift to the digital health environment, the resource capabilities of health systems in LMICs to support robust HIE is unknown. This study surveyed the status of resources for ICT to support ehealth communication in a resource-constrained setting. The study was conducted in three districts, representing the urban, peri-urban and rural settings of Uganda. The qualitative data collected was analysed with QSR NVivo 10. Results show major resource challenges including financial constraints, funders restrictions, human resource limitations, isolated computer systems, lack of support from management, legacy/outdated systems, intermittent/limited network bandwidth, limited hardware, misuse/poor maintenance of the available hardware, and power outages among others. In addition, results show a great disparity in their distribution across the healthcare sector. Therefore, we argue that much improvement is needed if the benefits of ehealth are to be attained in LMICs. Recommendations include specifying minimum resources for ICT required to support HIE, supervising implementation and monitoring compliance to the standards, establish a mechanism for periodic review of the minimum standards, and finally, align ICT funding within the mainstream funding for healthcare services. It should uniformly apply across the board (i.e., facilities located in urban, peri-urban and urban) for the full benefits of ICT in health to be achieved in LMICs.

1 INTRODUCTION

Low- and middle-income countries (LMICs) lag in development and lack of resources for the wellbeing of all (Andrews et al., 2012). The resource challenges extend to shortages in the healthcare system. However, ICT has found multiple applications in LMICs as they attempt to alleviate current resource shortages limiting service delivery in their healthcare sector, transportation, and governance among others. In fact, in their ICT policy document, Uganda's ministry of ICT identified applications of ICT for sustainable development to span the fields of public administration, business, education and training, health, employment, environment, agriculture, petroleum, science, oil and gas, as well as linguistic and cultural diversity (Uganda's MoICT, 2014). Particular to this study, is the need to leverage challenges in healthcare like high patient-physician ratio, variable quality of care, limited medical equipment, high cost of healthcare, corruption/fraud, and patient monitoring problem (Lewis et al., 2012; Madinah, 2016) by adopting ICT in support of health information exchange (Peña-López, 2010).

According to Health ICT Industry Group, (2009) ICT can help support Electronic Health Records (EHR), Chronic Disease Management Systems, Computerised Practitioner Order Entry (CPOE), Clinical Decision Support, Electronic Transfer of Prescription, Electronic Appointment Booking, Personal Health Record, Telemedicine, and RFID and Bar-coding. In fact, the use of ICT in healthcare are categorised into health education, hospital management system, health research, and health data management (FrontEnders Healthcare Services Pvt. Ltd, 2016; Lewis et al., 2012). These are geared towards alleviating healthcare resource challenges, a problem more pronounces in LMICs. Contrary to a report by Lewis et al., (2012) that ranked sub-Sharan Africa the third-best in use of technology-enabled

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programmes as a percentage of all programmes, these mostly LMICs continue to grapple with resource shortages in Healthcare.

Central to the use of ICT to support health (ehealth) is the communication infrastructure and supporting resources. In fact, the use cases are facilitated by a communication infrastructure with resources suitable to meet the stringent requirements in a healthcare environment. However, the ICT itself continue to face challenges in LMICs including resource limitations, security and privacy concerns (Blantz, 2010; Dhital, 2018). These constraints on ICT has a bearing on their application to healthcare. According to Blantz (2010), the resource challenges range from connectivity problems, power shortages to human and other nontechnical challenges. Among these are challenges specific to ehealth infrastructure intended to support health data handling and or information exchange. However, resource challenges may not be uniform across the healthcare system.

Resources distribution in LMICs tends to be along the urban, peri-urban and rural divide. No matter the kind of resource, they are spread across the structural divide, with better resources reducing from developed to least developed countries, from urban to rural settings (Henry, 2019; Jere et al., 2013; Kuntagod et al., 2014). Therefore, the resources for the communication infrastructure supporting ehealth need to be investigated across the general resource distribution divide. Our consideration of resources stems from the summarised definition of resources by Alvaro et al., (2010) from the conservation of resource theory. They believe resources are objects, conditions, personal characteristics, and energies that are valued for survival or that serve as a means of achieving these resources (Alvaro et al., 2010). Mindful that health information exchange needs to take place irrespective of the locality of the health facility; adequate data communication resources that span physical, structural and energy (Alvaro et al., 2010) are required to support such exchanges.

According to Alvaro et al., 2010, the three major concepts of Conservation of Resources (COR) theory that apply to this study are; one, resources are required for adaptation and change. Healthcare systems need to adapt to the electronic transfer of health data. Two, the threat of loss leads to the protection of assets/resources in this case protection of the CIT resources and data involved in the exchange. Three, resources must be optimized for adaptation. Given the resource-constrained, there is a need to optimise the available resources to achieve HIE in LMICs.

1.1 Health Information Exchange

It is the role of delivery systems and communities who intend to exchange health information, to set up the communication infrastructure (McCarthy et al., 2014) for such exchange. Health information exchange (HIE) is the secure, electronic movement of health-related information in a standard format between disparate sources and users (Williams et al., 2012). To facilitate HIE, existing communication resources need to be robust to be able to support healthcare processes and data communication. In this regard, the communication infrastructure both within and across health facilities must be properly designed and implemented to support healthcare processes and data exchange. Thereby supporting HIE to improve clinical decision-making and continuity of care, while reducing unnecessary use of services (McCarthy et al., 2014).

1.2 Why eHealth Communication Resources?

Other studies have used or identified among other resources *sufficient storage, transport capacity (data communication bandwidth), state-of-art hardware* as required to support health data sharing/ communications (Dixon, 2016; Sewell, 2014). The scarce telecommunication resources like the *spectrum*, *numbering,* and *rights of way* (Uganda's MoICT, 2014) may be considered per implementation of a communication system. To meet the time requirements of health data, the data communication system/network needs to be robust. In addition, network availability and performance are considered very critical in healthcare (Juniper Networks, 2015). In fact, Sewell, (2014) argues that sufficient network capacity and speed are critical for supporting current and future healthcare technologies and applications. In fact, Dixon, (2016) argues strongly for sufficient storage as well as transport capacity for data and or information exchange. Therefore, we argue that the capacity of the communication infrastructure is dependent on these resources, i.e., storage, transport capacity/ bandwidth, the spectrum, available hardware, and of course associated software platforms. If the health data communication infrastructure is to be robust, the design and implementation of ICT systems used within the healthcare facility, cabling and choice of cable category, implementation of interfaces that request access to health records, establishment of the modes of information exchange, security, access privileges and privacy, must follow strict guidelines.

To investigate the factor of resources that influence implementation of ehealth in LMICs, the

study sought to answer the research question of what minimal communication resources are required to support sharing of Health Information in resource-constrained settings, the study explores the following questions: (1) what is the perception of healthcare practitioners in resource-constrained settings regards role of ICT in health? (2) what ehealth communication infrastructure resources are currently available to resource-constrained settings? (3) what healthcare processes can the current ICT resources support? And (4) what are the recommended improvements to communication resources to support HIE in low resourced environments?

The rest of the paper is organised as follows: Section 2 presents the methodology followed to conduct the study. In Section 3, we present the results of the survey of the current status of resources that support electronic health communication infrastructure in Uganda. Finally, we discuss the results of the survey in Section 4 before presenting the conclusions and future works in Section 5.

2 METHODS

This was a qualitative study of communication resources that support HIE. The study involved, one, a literature review of health informatics literature from PubMed Central and Google scholar regards resources for ehealth communication in LMICs or developing countries. The literature review considered both peer-reviewed and grey literature that considered resources for ehealth communication to support HIE. We also reviewed the state of ICT resources that may support HIE in four LMICs.

Two, an exploration of communication resources available to health facilities in Uganda's health system to understand their support for healthcare processes and identify any resource limitations. Only health facilities at the level of health centres IV, district hospitals and regional referral hospitals were included in the survey. Nine health facilities were purposively chosen from the central, eastern and northern Uganda. The basis of choice is, first, on the basis that they handle a high volume of patients. Second, Uganda's ministry of health (MoH) and or implementing partners have supplied all of them with one form of ICT or the other. Third, representative of rural (05 health centres IV), peri-urban (02 peri-urban health facilities – district hospital and regional referral hospital) and urban setting (02 urban health facilities).

Interviews were conducted among hospital superintendents/directors, Incharges (an officer in charge of a health facility) of health facility, ICT administrators and records offices of the identified facilities. However, out of the eighteen (18) responses, only fifteen (15) were included in the analysis. Three (03) records were excluded because they had missing information. In order to identify the emerging themes, QSR NVivo 10 was used in the analysis of the qualitative data collected.

3 RESULTS

3.1 Review of Other Studies

Only nineteen (19) peer-reviewed and grey literature were used in the review. The key results from their synthesis regard the role of ICT in health, resources for ehealth communication infrastructure available to resource-constrained settings, minimal communication resources required to support HIE and challenges to use of ICT in low resourced environments are summarised below in Table 1. These were the basis of our survey of ICT resource that supports healthcare processes in LMICs, a case of Uganda.

Table 1: Themes emerging from the literature review.

Role of ICT in health
• Support data collection, analysis and storage
• Support for clinical decisions and diagnosis
• Support for messaging and data sharing
Resources for eHealth CI/T
• eHealth hardware
• Application software/technologies
• Mobile connectivity and Internet penetration
• Access to Power/ Electricity
• Literacy skills
• Security /privacy
Challenges
• Lack of affordable connectivity / bandwidth
• Poor infrastructure
• Deployment of inappropriate technologies
• Technology literacy challenges
• Improper involvement of key stakeholders
• Limited supporting resources like power
• Inadequate policies

3.2 Case Study of Uganda

Responses used in the analysis were obtained from key stakeholders from healthcare settings at the level of Health Centre IVs' and above in the study districts of Tororo and Lira in Uganda. The hospital/health facility superintendents, directors, Facility Incharges, ICT officers, records officers, and ICT users represent the decision-makers, implementers and users of ICT at

health facility levels in Uganda. Being the key stakeholders, their response presents a realistic account of the status of ICT at surveyed health facilities/districts. The response was distributed among the respondent categories as shown in Figure 1.

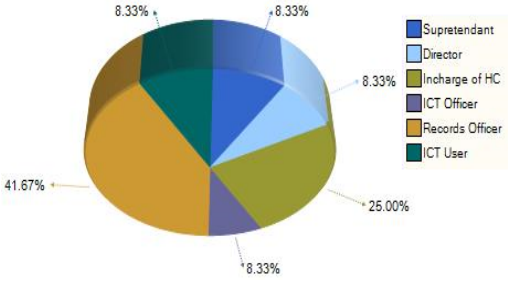

Figure 1: Distribution of responses by relevant positions.

Qualitative analysis was carried out using QSR NVivo 10. Emerging themes include use of ICT to support healthcare processes especially data handling and exchange, guidelines/standards for use, advantages of incorporating ICT in healthcare processes, current communication resources available in health facilities in the study districts, existing challenges, and recommended improvements. The results depict the views of different facility-level stakeholders. Most of whom were record officers (41.67%) who are the key users of ICT in the healthcare process and Incharges (25.0%), the decision-makers at facility levels. The rest i.e., superintendents, directors, ICT officers and ICT users, were equally represented at 8.33%.

3.2.1 Role of ICT in Healthcare

Results in Table 2 present the views of Uganda's health facility stakeholders on the role of ICT to healthcare processes. With uses ranging from administration, data storage, laboratory, monitoring, ordering, records, reporting, and research; various components of the ehealth CI/T are engaged to support health data/information exchange. Reported modes of health data exchange range from electronic to paper-based transfer within the facility, across facilities, or with the MoH headquarters.

They identified ICT use in healthcare that follows appropriate rules of data handling and exchange to be able to achieve the advantages of improved accuracy, monitoring, tracking, reliability of healthcare processes, and save on cost and time.

Hardware – the hardware (HW) resources include disks/tapes for data backup; computers (both desktops, laptops, portable digital assistants and phones) for computational tasks and communication; both local network and Internet resource to facilitate communication and health data sharing; and attached resources such as printers, scanners among others. These hardware resources need to be dedicated and robust to support data collection, processing, storage, output, and communication. To emphasise this need, a respondent called for "*computers and tablets should not be used to do anything else*".

Table 2: Role of ICT in health facilities.

Themes	Sub-Themes	# of respondents
Usage	Administration	2/15
	Data storage	3/15
	Laboratory	1/15
	Monitoring	2/15
	Ordering	2/15
	Records	7/15
	Reporting	6/15
	Research	1/15
	Others	2/15
Support for Health Information Exchange	Electronic	9/15
	Interfacility	3/15
	Intra-facility	6/15
	Mode of exchanges	6/15
	Paper-based	1/15
	Rules for exchange	3/15
Advantages	Improved accuracy	3/15
	Improved monitoring and tracking	2/15
	Improved reliability	1/15
	Saves Money	1/15
	Time-saving	2/15

Software – the software (SW) systems and technologies that were identified as in use by the surveyed health facilities include simple database systems, DHIS2, eHMIS, HIS, HR Biometric system, Medical Records, mTrac, Staff Recruitment System, and Tally Sheets.

Human Resources – respondents identified the need for digitally enabled human resources for healthcare. They strongly highlighted the need for in-service training of staff and or recruitment of digital health workers.

Electric Power – is required to ensure that the available hardware resources are powered to participate in data handling and communications. In fact, it powers the ICT equipment to ensure they function with a large meantime between failure.

- ***Resources Challenges:*** the use of ICT in different domains continues to experience challenges including resource challenges. In a similar manner, the ehealth communication infrastructure required to facilitate health information exchange in low-resourced settings experiences resource challenges.

Among the identified challenges are financial constraints, funders restrictions, HR limitations, isolated systems-computers, lack of support from management, legacy / outdated systems, limited network bandwidth, and the intermittent Internet, limited use-access, limited hardware, misuse and poor maintenance of the available hardware, and power outages. The number of respondents who agreed on the existence of each of these challenges in their facilities are summarised in Table 4.

Table 3: eHealth and supporting resources.

Resource type	# of respondents
HW-Storage Hard disks/Tapes	1/15
Computers, laptops, PDAs, etc	9/15
Local area network & Internet	6/15
Printer	1/15
Scanner	2/15
SW-Systems & Technologies	
Database	2/15
DHIS2	1/15
eHMIS	1/15
HIS	1/15
HR Biometric system	2/15
Medical Records	1/15
mTrac	2/15
Staff Recruitment System	1/15
Tally Sheets	1/15
HR -Available HR	2/15
- HR Training	4/15
Power	1/15

Table 4: Challenges to the use of ICT in Health Facilities.

Challenges	# of respondents
Financial constraints	4/15
Funders interest	2/15
HR limitations	5/15
Isolated systems-computers	3/15
Lack of support from management	2/15
Legacy / outdated systems	3/15
Limited BW-Internet	3/15
Limited HW	2/15
Limited use-access	3/15
Misuse & poor maintenance	2/15
Power	3/15
Others	6/15

Other challenges that may negatively influence adoption and use of ICT in healthcare were identified as missing technologies, the inexistence of the ICT department, improper/unbalanced planning for the ICT department, and limitation in the digital health skills of their workers.

- ***Security / Privacy Guidelines:*** there are various threats to the electronic sharing of health data (11/13). However, these threats can be minimised by a set of guidelines on the use of ICT in healthcare. Among the standards identified as required to regulate the use of ICT in healthcare are access restrictions whether physical, password, pin, unique patient or practitioner codes and access logs (see Table 5). Management plays a key role in the development and enforcement of such guidelines.

Table 5: Current security and privacy guidelines for handling health data in a digital environment.

Sub-Themes	# of respondents
Threats	11/15
Privacy and security measures	
Access-Log	1/15
Restrictions	6/15
Unique codes	
Patient unique code	4/15
Practitioner unique code	3/15
Role of management	2/15

- ***Suggestions for Improvement:*** table 6 present views of respondents on how the use of ICT can be improved to better serve healthcare processes. Their views included the provision of data backup storage, minimising ICT resource challenges that were summarised in Table 4, better management, training of staff in digital health skills, better stakeholders' involvement, and adoption of user-friendly and supportive technologies.

Table 6: General views on improving ICT for health.

Sub-Themes	# of respondents
Data Storage	1/15
Improved resources	3/15
Management role	3/15
Training	5/15
Stakeholders	2/15
Supportive technologies	1/15

Further analysis was done, first, to examine the distribution of the resources for ICT across the urban, peri-urban and rural setting. Results show unequal distribution as presented in Figure 2. The resources are high in health facilities in urban settings and decrease tremendously in rural settings. In fact, similar resource categories in a rural setting are under half those in urban settings. Second, to explore how the responses vary by categorises of respondents. Respondents were categorised into superintendents of regional referral hospitals and directors of district hospitals, medical officers who are in charge of

Health Centre IVs, officers in charge of ICT in the respective referral and district hospitals, record officers at the level of Health Centre IVs and district hospitals, and ICT users at the surveyed health facilities. The result presented in Figure 3 shows strong views were expressed by the In charge of health facilities, ICT officers and Records officers. Counts in Figure 3 represents the number of times respondents expressed strong views concerning the identified themes.

Third, we compared results from the survey of Uganda to those obtained from the literature review of four other LIMCs in Africa. With the exception of available bandwidth, the results presented in Table 7 show Uganda has similar or even better ICT resources when compared to the four reviewed LMICs.

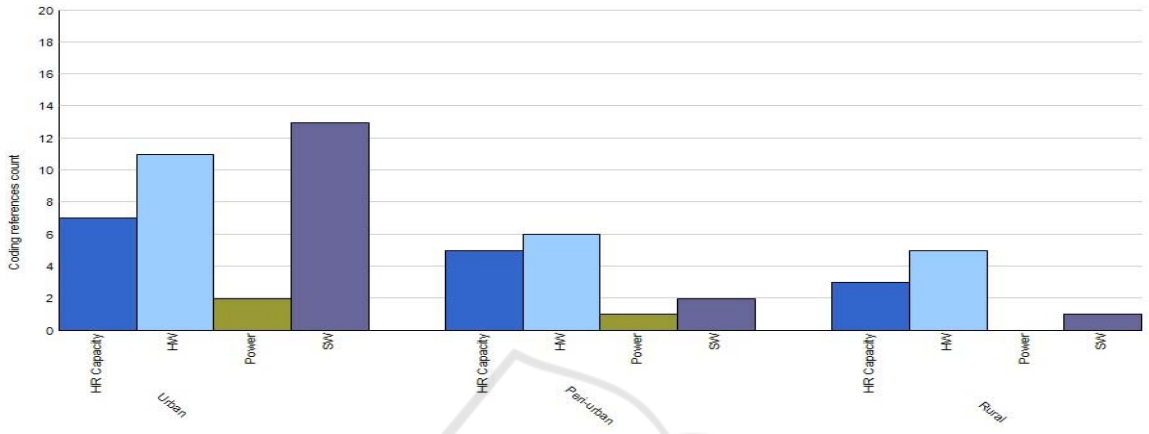

Figure 2: Urban, peri-urban and rural distribution of CIT resources.

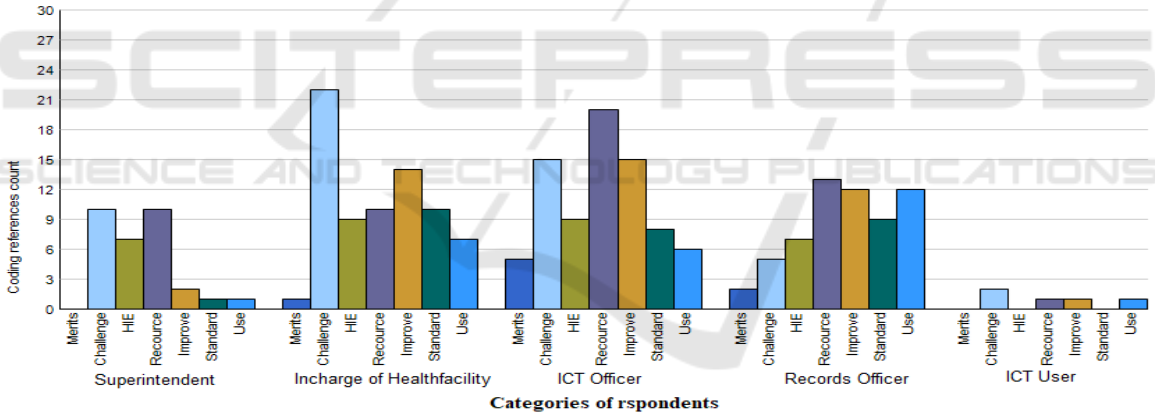

Figure 3: Distribution of responses by respondent categories.

Table 7: Comparing the state of ICT resources in Uganda to other Four LMICs in Africa (ITU, 2019; WHO & ITU, 2015; Asingwire, 2018; Bhatia et al., 2015; and Uganda's MoICT, 2018).

Resources	Kenya	South Africa	Rwanda	Tanzania	Uganda
Average available Bandwidth (Mbps)	12.2	6.7	— —	— —	4.0
Internet penetration	×—	✓—	××	××	×—
Mobile Network connectivity	— —	✓✓	✓×	✓—	✓×
Hardware resources	××	×—	××	××	××
Security /privacy	×—	×—	— —	— —	✓×
Literacy skills	×—	××	××	— —	✓×
Access to Power	✓—	— —	✓✓	✓×	××

Key: ✓✓=Very High (above 80%), ✓—=High (61%-80%), ✓×=Medium (41%-60%), ×—=Low (21%-40%), ××=Very Low (below 21%), — —=Not sure/missing information.

4 DISCUSSION

The hardware and software resources should be robust enough to provide a reliable transport environment for data sharing. Remembering that resources must be optimized for adaptation (Alvaro et al., 2010), the healthcare environment requires robust processing power and communication capacity to meet the stringent life-saving time requirements. The results show a discrepancy in requirements for the resources like the one suggested by HealthIT, (2013) and those identified for Uganda. Whereas the practitioners expressed aspiration for state-of-the-art CI resources, the ministry recommended improved equipment, existing resources for ehealth CI remains limited in Uganda's health system. These recommendations are in line with the suggestions by respondents for resource improvement, e.g., MoH "*need to install reliable internet service*", "*provide power backup sources*", and "*Computers in all the departments and these computers can be networked*". Not only are appropriate resources for the CI required, but also a proper design and implementation that furthers the aims of healthcare delivery (McCarthy et al., 2014). For HIE and interoperability to exist across the healthcare system, the design and implementation of such infrastructure need to follow agreed standards.

Whereas a previous study identified multiple ehealth technologies in Uganda's healthcare environment (Huang et al., 2017), this survey only identified nine software technologies. This could partly be attributed to failure to sustain donor technologies after the project duration, or lack of skills to continue their use or financial constraints among others. The initiative by Uganda's MoH to promote technologies like DHIS2 and mTrac in a drive to promote standardisation of interoperable systems could have also discouraged the use or further adoption of diverse systems. Whatever the software system / technology, it must be robust to perform the required tasks as stated by a respondent "*All you need is very robust software systems, once you have it the others can be automatic*". However, network connectivity remains poor in rural areas. This hampers HIE efforts. An earlier study on the practical challenges for large-scale deployment of mHealth solutions in LMICs confirms it, saying "*for always-on data, connectivity does not work when deployed in rural…*"(Kuntagod et al., 2014).

The disparity in the distribution of resources is attributed to a lack of standards to guide the establishment of the ehealth communications infrastructure, financial limitations, and limited support or improper prioritisation by management. For example, whenever the mains power supply is off, there is a lack of a fails-over power backup supply in the form of no fuel to run the generators, or failed solar installation, etc.

In fact, identified challenges to use of ICT resources in health majorly centre around a limitation in financial resources as summarised in this response:

"*We have very limited budget, data, for example, is not easily affordable. We normally take advantage of partners who have interest in certain things and avail data for this and this. Otherwise, our budget is very limited. We can't support the ICT sector effectively. The hardware has wear and tear, the maintenance cost is very high*".

Existing ICT resources are donor-funded, confirming the arguments of Huang et al., (2017); however, they come with stringent restrictions on use. Sustainability tends to last for only the duration of the funding. Technologies in use are able to improve healthcare processes, for example, the monitoring and supplies tracking system is able to expose corrupt behaviours thereby saving on money. "B*ecause you can monitor all the vouchers and the transactions from the stores and can count how many tablets were used. This would help save a lot of money*".

As regards the role of ICT in healthcare, we argue that, although ICT presents much promise to support HIE, existing communication resources are still inadequate in Uganda's health system. Multiple-use cases of ICT in healthcare have been highlighted in these resource-constrained settings (Lewis et al., 2012), however, the advantages are still restricted to administrative tasks. There is a need to extend this to HIE related processes. Similar dilemma including the problem of the cross-system linkup, lack of commonly defined and consistently implemented standards, privacy/security concerns, cost of implementation, and availability of necessary infrastructure like power, Internet, among others (Lewis et al., 2012; Peña-López, 2010) exist in other resource-constrained healthcare settings.

In further analysis, first, we discovered that the resource decreases uniformly from urban to the rural healthcare settings, with power tending towards zero in the rural health facility. This high-power outage without an alternative source of power requires immediate action as called for by a respondent "*Something must be done about this frequent power interruption*". We acknowledge that respondents in urban settings expressed the strong presence of software resources (SW) above other resource categories as represented in Figure 2. This is possible because the first stopover for new technological innovations is in urban health facilities and only a few

scales over to rural settings. Also, the availability of supporting resources like power, internet, technical human resource, etc may be enabling factors.

Second, we realised that although ehealth users were majorly from urban settings where there are more ICT resources, they couldn't state the advantages of ehealth in facilitating healthcare processes (see Figure 3). It was also surprising that the interviewed superintendents and directors couldn't properly state the advantages of ehealth. Overall, the facility managers and direct users of ehealth technologies expressed little opinion on the merits of the use of using ICT in healthcare as compared to their counterparts, the Incharge of health centre IVs, ICT officers and records officers. This shows the managers are disengaged from decisions regards acquisition and use and possibly ICT are imposed on them by NGOs, implementing partners and or governments. The users lack proper orientation to adopt the use of ICT and therefore find it difficult to use. This could explain why many respondents recommend management support and training. "W*e need training of staff. Some people might have not been trained, so they find difficulty in handling it*".

Third, a comparison of the state of resources for ICT in four other LMICs in Africa indicate that Although Uganda has not yet achieved much progress regards electronic HIE, her ICT resource environment is similar or even better than some of the countries that have made much progress. In fact, other LMICs who are hesitant on adapting ehealth in support of their healthcare services can learn from this comparison.

5 CONCLUSIONS

The survey of ICT resources being used in health to support ehealth communication in three regions of Uganda revealed major challenges to the acquisition, establishment, and management of the ehealth communication infrastructure. Furthermore, the resource distribution is unevenly spread across the rural, peri-urban and urban settings. Both these challenges and the uneven spread negatively influence health information exchange both within a health facility and across health facilities respectively. Although the survey only involved three districts in Uganda, we believe the findings from this study are representative of the status of ehealth communication resources in the whole country.

The findings of this study can inform Uganda's MoH (and any other resource-constrained LMIC) to standardise the ehealth communication infrastructure of their healthcare systems. Recommendations for improvement include; (1) the MoH needs to specify minimum resources for ICT required to support HIE, both within and across healthcare organisations. This includes standardisation of the design and implementation of ICT systems to support HIE. The technology systems at the healthcare facility level, the cabling and cable category, interfaces, modes of information exchange, security, access privileges and privacy need to be standardised. (2) The MoH needs to supervise implementation and monitoring compliance to the standards. Changes to be implemented may include those that create a uniform enabling environment for HIE, for example, connect all health facilities to the national backbone, provide alternative power sources like solar power, etc. (3) Establish a mechanism for periodic review of the minimum standards for ICT supporting HIE. And finally, (4) Align ICT funding within the mainstream funding for healthcare services.

In another ongoing study, we are reviewing global standards for ehealth CI/T to determine criteria for selecting standards suitable to support HIE in LMICs. We also intend to develop a structured process that can be used by LMICs to adopt standards for ehealth CI/T, monitor implementation and compliance with such standards.

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REFERENCES

Alvaro, C., Lyons, R. F., Warner, G., Hobfoll, S. E., Martens, P. J., Labonté, R., Brown, E.R., 2010. Conservation of resources theory and research use in health systems. Implementation science 5, 79.

Andrews, C., Das, M., Elder, J., Ovadiya, M., Zampaglione, G., 2012. Social Protection in Low Income Countries and Fragile Situations: Challenges and Future Directions. World Bank 59.

Asingwire, N., 2018. The high cost of mobile data in Sub-SaharanAfrica [WWW Document]. SautiTech. URL https://www.sautitech.com/telecom/uganda-has-the-most-expensive-internet-in-east-africa-report/ (accessed 6.20.19).

Bhatia, M., Angelou, N., Soni, R., Portale, E., Fletcher, E. R.., Susan Wilburn, Adair-Rohani, H., 2015. Access to Modern Energy Services for Health Facilities in

Resource-Constrained Settings: A Review of Status, Significance, Challenges and Measurement. World Health Organization and World Bank.

Blantz, E., 2010. 4 Key Challenges and Solutions to ICT Deployments for Rural Healthcare. ICTworks. URL https://www.ictworks.org/4-key-challenges-and-solutions-ict-deployments-rural-healthcare/ (accessed 10.24.19).

Dhital, H., 2018. Opportunities and Challenges to Use ICT in Government School Education of Nepal. International Journal of Innovative Research in Computer and Communication Engineering 3215–3220.

Dixon, B. E., 2016. What is Health Information Exchange? In: Health Information Exchange : Navigating and Managing a Network of Health Information Systems. pp. 3–20.

FrontEnders Healthcare Services Pvt. Ltd, 2016. Information Communication Technology in HealthCare [WWW Document]. URL https://www.frontenders.in/blog/information-communication-technology-healthcare.html (accessed 10.21.19).

Health ICT Industry Group, 2009. ICT's Role in Healthcare Transformation.

HealthIT, 2013. What is the recommended bandwidth for different types of health care providers? [WWW Document]. URL https://www.healthit.gov/faq/what-recommended-bandwidth-different-types-health-care-providers (accessed 5.22.19).

Henry, L., 2019. Bridging the urban-rural digital divide and mobilizing technology for poverty eradication: challenges and gaps. University of the West Indies, St Augustine, Trinidad and Tobago.

Huang, F., Blaschke, S., Lucas, H., 2017. Beyond pilotitis: taking digital health interventions to the national level in China and Uganda. Globalization and Health 13, 49. https://doi.org/10.1186/s12992-017-0275-z

ITU, 2019. ICT Country Profile [WWW Document]. URL https://www.itu.int/net4/itu-d/icteye/CountryProfile.aspx#AsiaPacific (accessed 5.22.19).

Jere, N. R., Thinyane, M., Boikhutso, T., Ndlovu, N., 2013. An assessment of ICT challenges in rural areas: ICT experts vs rural users views: a case of the Siyakhula Living Lab, in: Proceedings of the South African Institute for Computer Scientists and Information Technologists Conference. ACM, pp. 233–241.

Juniper Networks, 2015. Five Requirements for Building a State-of-the-Art Healthcare Network from the Ground Up 6.

Kuntagod, N., Paul, S., Kumaresan, S., Ganti, S., 2014. Practical challenges for large-scale deployment of mHealth solution insights from a field trial, in: IEEE Global Humanitarian Technology Conference (GHTC 2014). IEEE, pp. 235–241.

Lewis, T., Synowiec, C., Lagomarsino, G., Schweitzer, J., 2012. E-health in low-and middle-income countries: findings from the Center for Health Market Innovations. Bulletin of the World Health Organization 90, 332–340.

Madinah, N., 2016. Challenges and barriers to the health service delivery system in Uganda. IOSR Journal of Nursing and Health Science 5, 30–38.

McCarthy, D. B., Propp, K., Cohen, A., Sabharwal, R., Schachter, A. A., Rein, A. L., 2014. Learning from Health Information Exchange Technical Architecture and Implementation in Seven Beacon Communities. EGEMS (Wash DC) 2. https://doi.org/10.13063/2327-9214.1060

Peña-López, I., 2010. Improving health sector efficiency: The role of information and communication technologies.

Sewell, A., 2014. Meeting network infrastructure challenges [WWW Document]. Healthcare Innovation. URL https://www.hcinnovationgroup.com/policy-value-based-care/article/13006987/meeting-network-infrastructure-challenges (accessed 5.23.19).

Uganda's MoICT, 2018. The National Broadband Policy.

Uganda's MoICT, 2014. National Information and Communications Technology Policy for Uganda.

WHO & ITU, 2015. Atlas of eHealth country profiles 2015: The use of eHealth in support of universal health coverage [WWW Document]. WHO. URL http://www.who.int/goe/publications/atlas_2015/en/ (accessed 2.28.19).

Williams, C., Mostashari, F., Mertz, K., Hogin, E., Atwal, P., 2012. From the Office of the National Coordinator: the strategy for advancing the exchange of health information. Health affairs 31, 527–536.